Battlefield Advances
Remarkable innovations in treating injured soldiers will ultimately benefit us all

By Michael J. Weiss

Hot dust choked the air over the desert outside Rawah, Iraq. It wasn't even noon last June 27, but already the temperature had climbed to 100 degrees. Perched in the gun turret of his Stryker light-armored vehicle, U.S. Army Staff Sgt. Jacque Keeslar surveyed the dirt road ahead while on a mission to raid a safe house for suspected insurgents. As his patrol sped through the dusty landscape, 36-year-old Keeslar never saw the improvised bomb buried beneath the road. Suddenly an explosion ripped through the vehicle with a roar. "Oh my God!" cried Keeslar as he frantically tried to pull himself out of the turret. "I'm hit!"

Three out of five soldiers in the Stryker sustained serious injuries, but his were the worst: The blast had shredded both his legs. Within 48 hours, surgeons in Germany amputated his right leg below the knee and his left one at the kneecap. "I don't remember when I realized my legs were gone," says Keeslar today. "All I could think about was starting the recovery process so I could walk again."

A mere four months after the attack, Keeslar is getting his wish. At Walter Reed Army Medical Center in Washington, D.C., he strides around the physical therapy center with barely a hitch in his gait. Beneath baggy sweatpants and jogging shoes, he wears a revolutionary prosthetic device known as a C-Leg, so named because of a computer microprocessor in the knee that makes 50 calculations per second to adapt to a user's gait.

While in previous wars the loss of a leg meant a lifetime of restriction, service members like Keeslar can reclaim their independence thanks to the $50,000 C-Leg, a wonder of titanium, graphite and technology made by Germany's Otto Bock HealthCare. At Walter Reed, technicians programmed his C-Leg's circuitry to keep him stable and upright - no matter than surface or angle of terrain.

With a C-Leg on his left side and a mechanical prosthetic on his right, Keeslar soon began to walk naturally, climb stairs and return to a normal life with his wife, Vanessa. Last November, he competed in the New York City Marathon, riding a hand-cranked recumbent bicycle to reach the finish line of the 26-mile course in a little over three hours. This year, he hopes to return to active duty as an instructor at Fort Knox, Kentucky, and looks forward to spending weekends riding his Harley-Davidson motorcycle. "As soon as I put on the C-Leg, I was walking again," Keeslar says. "It's an awesome piece of equipment."

Though Keeslar's recovery seems miraculous, military medical marvels like his C-Leg are becoming increasingly common. Since the war in Iraq began in 2003, Americans have suffered more than 3,000 deaths and about 23,000 casualties. But the conflict has produced an unexpected payoff: remarkable advances in treating trauma and injuries. Military doctors and researchers are making impressive gains in healing injured soldiers and rehabilitating them to active lives. And many of these innovations are finding their way to general medical use, aiding civilians as well as troops. Against the backdrop of a divisive war in the Middle East, here are several heartening advances in military medicine that have the power to help us all:

NEURO RESCUE

Most military doctors once considered traumatic brain injuries (TBIs) received in combat to be fatal. Less than ten percent of soldiers survived severe head injuries, and fewer than five percent went on to lead independent, functioning lives. But when coalition forces landed in Iraq

in 2003, a group of eight U.S. neurosurgeons and neurologists decided to try a new front-line approach to TBIs called damage control neurosurgery, or neuro rescue.

Stationed at the 28th Combat Support Hospital near Fallujah, they developed a technique that involved delicately removing part of a patient's skull to allow the brain to swell instead of put pressure on the brainstem, which could cause irreversible coma. After closing the scalp, doctors ensure the brain receives plenty of blood by using micro-balloons and medication to unclog any narrowing blood vessels-treatment similar to what stroke victims receive. After several months, once the brain swelling recedes, doctors use a computer-generated model of the patient's head to create a hard acrylic implant that they insert when closing up the skull.

For this bit of medical wizardry, the doctors were nicknamed the Skull Crackers. "Our breakthrough was in treating a traumatic brain injury like a stroke," says Rocco Armonda, MD, one of the Skull Cracker neurosurgeons now serving at National Naval Medical Center in Bethesda, Mayrland. "If you can open the skull early enough to prevent secondary injuries like low blood flow, the chances of recovery are better than ever." Indeed, Dr. Armonda estimates that the survival rate of neuro-rescued brain trauma victims has risen to more than 50 percent and more than a third have returned to independent living - working, driving a car and even attending college.

Meanwhile, neuro-rescue techniques are slowly being adopted in hospitals in the States, where 1.4 million Americans suffer TBIs every year. After ABC News anchor Bob Woodruff sustained a brain injury in Iraq, he received the pioneering treatment under Dr. Armonda's care last winter.

ULTIMATE BANDAGE

Since the dawn of warfare, a major killer of soldiers on the battlefield has been severe bleeding. Even today in Iraq and Afghanistan, many of those who die in combat bleed to death in the minutes before they can be evacuated to an aid station. But that tragic toll may soon decline with the development of an innovative dressing called the HemCon Bandage. Made with chitosan (pronounced KY-tuh-san), it uses an organic substance from shrimp shells to help blood cells form clots. A four-inch-square dressing can staunch a heavily gushing wound in 30 seconds and has been shown to stop or reduce bleeding in more than 90 percent of combat cases.

"It acts like a tire patch," says Col. Robert Vandre, the U.S. Army's director of Combat Casualty Care Research at Fort Detrick, Maryland. "It's not sticky until it gets in the presence of blood. Then it adheres to the surrounding tissue and seals off the blood like no other conventional bandage."

Created by scientists at the Oregon Medical Laser Center under a grant from the U.S. Army Medical Research and Materiel Command, the HemCon (for "hemorrhage control") Bandage works because the positively charged chitosan material bonds with negatively charged blood cells to form an artificial clot. When researchers first demonstrated the bandage's effectiveness in 2002, the Food and Drug Administration gave it fast-track approval in a matter of days. Since then, the Army has made the $85 bandage standard issue for all American soldiers serving in Iraq and Afghanistan. And military reports credit the bandage with already saving more than 100 lives. In mid-2006, the manufacturer, Portland-based HemCon Medical Technologies, Inc., began marketing the bandage to civilian medical personnel, including ambulance drivers and emergency room doctors.

FUTURE DOG TAGS

Tommy Morris knows the challenges of battlefield medicine. As a front-line medic with the Army's Third Infantry Division in 1993, he struggled to treat the soldiers under his care in war-torn Macedonia. Frustrated by rainstorms soaking through paper medical reports, he vowed to bring medical recordkeeping into the digital age. "I kept thinking, There's got to be a better way," recalls Morris, now 38 and chief information technology officers at the Army's Telemedicine and Advanced Technology Research Center in Fort Detrick.

In 2001, Morris created that better way by designing a new software product called BMIST, which allows medics to enter casualty information into a handheld device. Short for Battlefield Medical Information System-Tactical (and pronounced "bee mist"), the software allows medics to generate an electronic health record about a soldier for later retrieval by frontline doctors or a stateside hospital. In addition, it acts like a medical textbook so medics can look up diagnostic and treatment information in a combat zone. Already, BMIST software has been licensed to military departments and civilian hospitals in the United Kingdom. Pilot programs are being set up in France and Canada. First responders in the United States are also using it to record medical information on victims of disasters like Hurricane Katrina.

But BMIST is only one of several advances revolutionizing the management of patient information. Since 2005, the U.S. Army Medical Research and Materiel Command has experimented with the Electronic Information Carrier. The EIC is a dog tag-size wireless data device worn by soldiers that can store up to two gigabytes of data-literally thousands of pages of records. Rather than having to search through a soldier's uniform for information on blood type or allergies, medical personnel can easily access that information up to 30 feet away with the electronic dog tag.

At the same time, all the military branches are adopting an all-digital medical information system through an initiative called Armed Forces Health Longitudinal Technology Application (AHLTA). Its goal is to electronically track the illnesses, allergies and prescribed medicines of all 9.2 million service members and veterans. When these advances are combined, medical workers will have access to the complete health records of even unconscious soldiers. This will allow them to determine whether a person has been exposed to a chemical agent, and it will also prevent deadly drug interactions. Over the past five years, AHLTA has identified and resolved more than 200,000 potentially life-threatening drug conflicts.

But Morris believes these benefits are only the beginning. He foresees integrating BMIST with a sensor that will automatically alert a doctor when a veteran's pacemaker is malfunctioning - "like in Star Trek," he says. And medics in the near future will be able to wave a handheld BMIST device over a wounded soldier, save the patient's vital signs on an EIC, and take comfort in knowing that the medical chart will follow the patient for the rest of his life.

SMART PAIN BLOCKERS

For over a century, doctors have treated seriously wounded soldiers with morphine, all the while knowing the narcotic's downsides. It impairs breathing, reduces decision-making abilities, and if taken over time, can be addictive. But three years ago, researchers funded by the Defense Advanced Research Projects Agency (DARPA) reported a remarkable alternative: a non-addictive pain blocker. While investigating the biochemical origins of pain, they developed an experimental drug-actually, a synthetic antibody known as RN624-that inhibits a molecular pain messenger called nerve growth factor. The powerful antibody keeps the brain from receiving pain messages sent by nerve endings surrounding an injury. And the drug is long-lasting; a single dose can block pain for several weeks. Best of all, it has no addictive side effects.

A wounded soldier may get one dose on the battlefield that can take care of any pain until he's evacuated to a hospital days later," says Brett Giroir, MD, deputy director of DARPA's Defense Sciences Office in Arlington, Virginia. RN624 was developed at Palo Alto-based Rinat Neuroscience Corporation, which was bought by Pfizer last year. Pfizer is conducting clinical trials on the drug and hopes to market it. According to Dr. Giroir, "This could revolutionize the way we treat pain."

PROSTHETICS WITH THOUGHT CONTROL

While some of the military's medical initiatives are years away from fruition, they have astonishing promise. At DARPA, it's hoped that an ambitious four-year, $48 million Revolutionizing Prosthetics Program will result in the creation of artificial human arms and hands controlled by brain waves. Already, researchers have found success with primates. At the University of Pittsburgh, scientists taught a monkey to feed itself using thought-generated impulses picked up by the electrodes of a prosthetic arm. "The monkey was able to move the robot arm out, grab a zucchini chip and bring it back to its mouth just by thinking these motions," says Col. Geoffrey Ling, M.D., program manager of DARPA's Defense Sciences Office. "It was phenomenal."

The next goal is to adapt the technology to people, says Dr. Ling, and scientists are conducting the first human trials with paraplegics and patients who have Parkinson's disease. DARPA's timetable calls for completing a working prosthetic arm and hand by the end of the year that will look, feel and perform like natural limbs. Two years later, it hopes to apply for FDA approval for a working, neurally controlled model.

Having served as a military physician in Afghanistan and Iraq, Dr. Ling knows the urgency in bringing these advances to life - "for the good of the troops," he says. But he also knows that medical breakthroughs born of war aid all humanity: Blood banks, penicillin and reconstructive surgery all emerged from past conflicts. "Perhaps through-controlled prosthetics will be one of the miracles that comes out of the war in Iraq," says Dr. Ling. "In adversity, there's opportunity."

(to view a photo slide show of Staff Sgt. Jacque Keeslar's recovery, visit rd.com/C-Leg)